National Superconducting Cyclotron Laboratory at Michigan State University

Thomas Glasmacher
Assoc. Dir. for Operations, NSCL

2008 NSF Large Facilities Workshop
April 7, 2008 – Boulder

National Superconducting Cyclotron Laboratory at Michigan State University

- NSCL
- Research thrusts
- Quality
- Safety
- Environment
- Third-party audited management systems
- Human resources

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NSCL

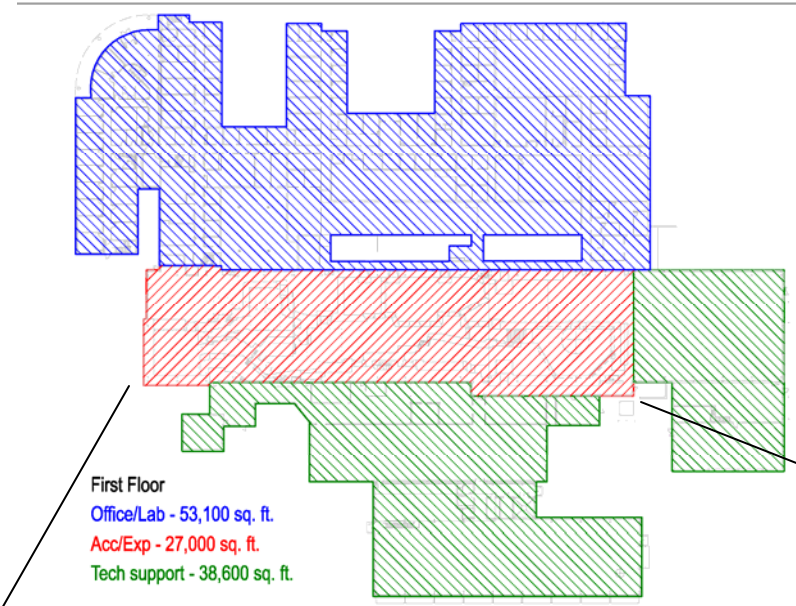
National Superconducting Cyclotron Laboratory

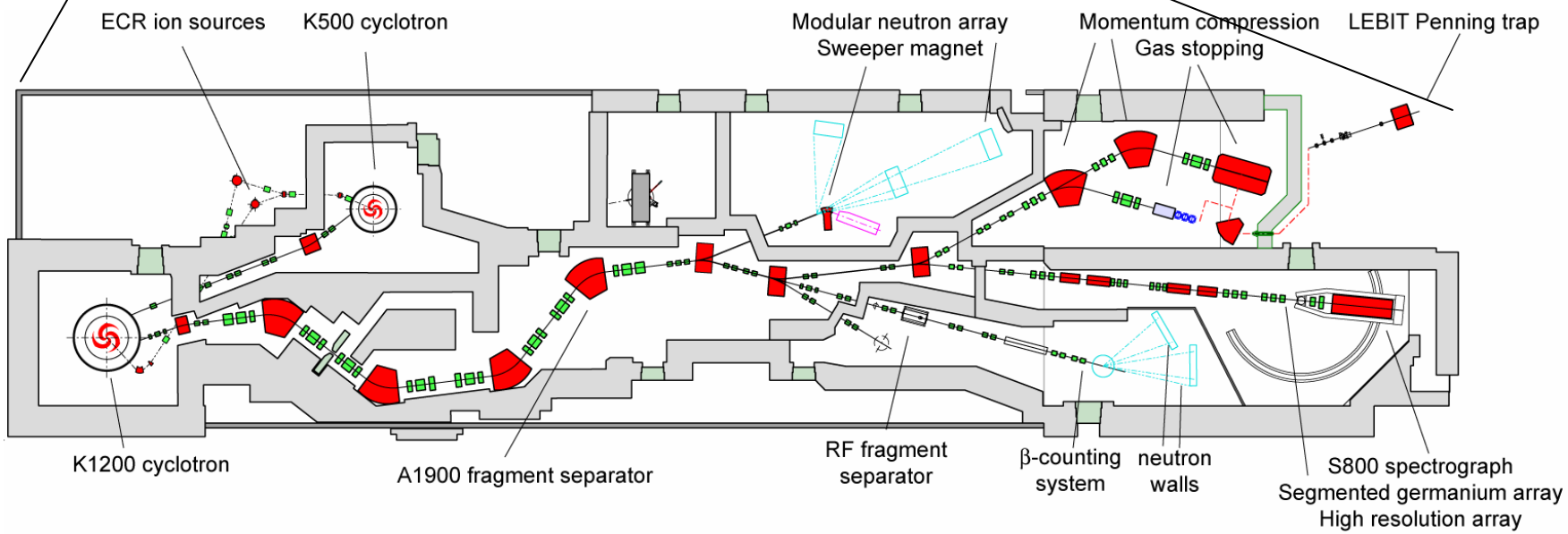
- National user facility for rare isotope research and education in nuclear science, astro-nuclear physics, accelerator physics, and societal applications
- Located on the campus of Michigan State University in East Lansing
- One of the three nuclear-science flagship facilities in the US (RHIC at BNL, CEBAF at JLAB, NSCL at MSU)
- Largest university-based nuclear physics laboratory in the U.S. – 10% of U.S. nuclear science Ph.D.s
- 310 employees, incl. 62 undergraduate and 57 graduate students, 30 faculty – over 700 users
- Graduate program in Nuclear Physics ranked 2nd (behind MIT) (U.S. News and World Report)
- NSCL provides accelerated beams of heavy ions (from hydrogen to uranium) including rare isotope beams
- Nation's premier rare isotope facility with "world-leading capabilities with fast rare-isotope beams" (NSAC 2007 Long Range Plan for Nuclear Science, page 9)

NSCL

NSCL floor plan

- 53,100 sqft office and laboratory
- 27,000 sqft accelerator and experimental
- 38,600 sqft technical support (cryoplant, assembly, 1000 sqft clean room, CNC machine shop, ...)





Major research thrusts at NSCL

- Production of nuclei with unusual ratios of protons to neutrons and measurement of their properties – connection to mesoscopic science*

  What are the limits of nuclear existence? What are the properties of nuclei with extreme ratios of protons and neutrons (neutron skins and halos)? Modification of shell structure, new doubly magic nuclei: ^{48}Ni, ^{78}Ni, ^{100}Sn, ^{132}Sn...

- Exploration of the nuclear processes responsible for the chemical evolution of the universe through the ongoing synthesis of most elements in the cosmos – connection to astrophysics**

  Where are most of the nuclei heavier than iron made? How do supernovae explode? Are Type 1a SN good standard candles?

- Exploration of the isospin dependent properties of hot nuclear matter and how they affect supernovae and neutron star properties – connection to astrophysics**

  What is the equation of state (EOS) of neutron-rich nuclear matter?

- Exploration and tests of novel superconducting accelerator and beam transport concepts and the dynamics of high-intensity beams***

  One of the few universities that graduates accelerator physics/engineering PhDs

* Mesoscopic Theory Center at MSU

** JINA (Joint Institute for Nuclear Astrophysics, NSF Frontier Center)

*** Member of USPAS (U.S. Particle Accelerator School)

NSCL

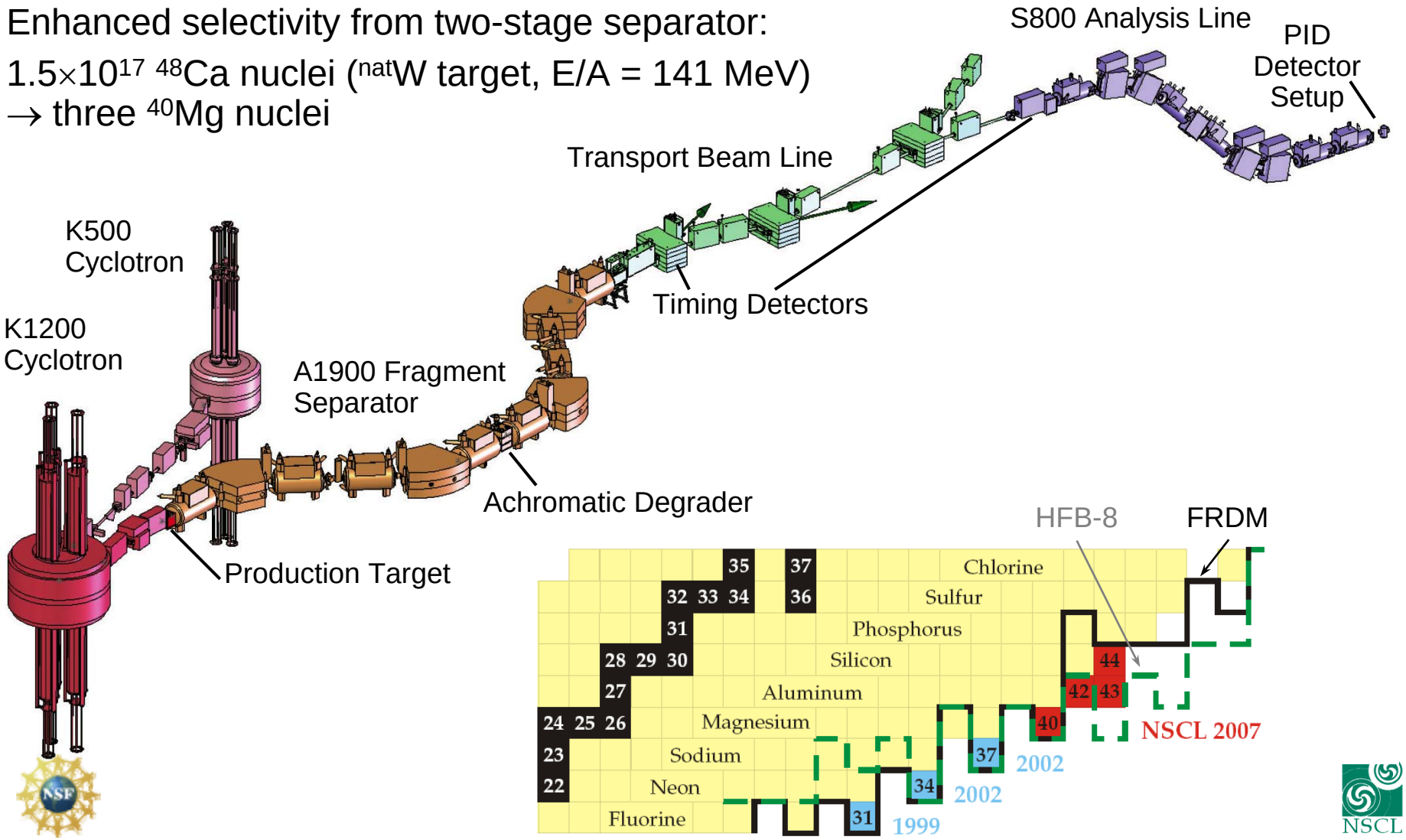
Discovery of ^{40}Mg, ^{42,43}Al, and ^{44}Si in 2007

Baumann *et al.*, Nature **449** (2007) 1022; Phys. Rev. C75 (2007) 064613;

Enhanced selectivity from two-stage separator:

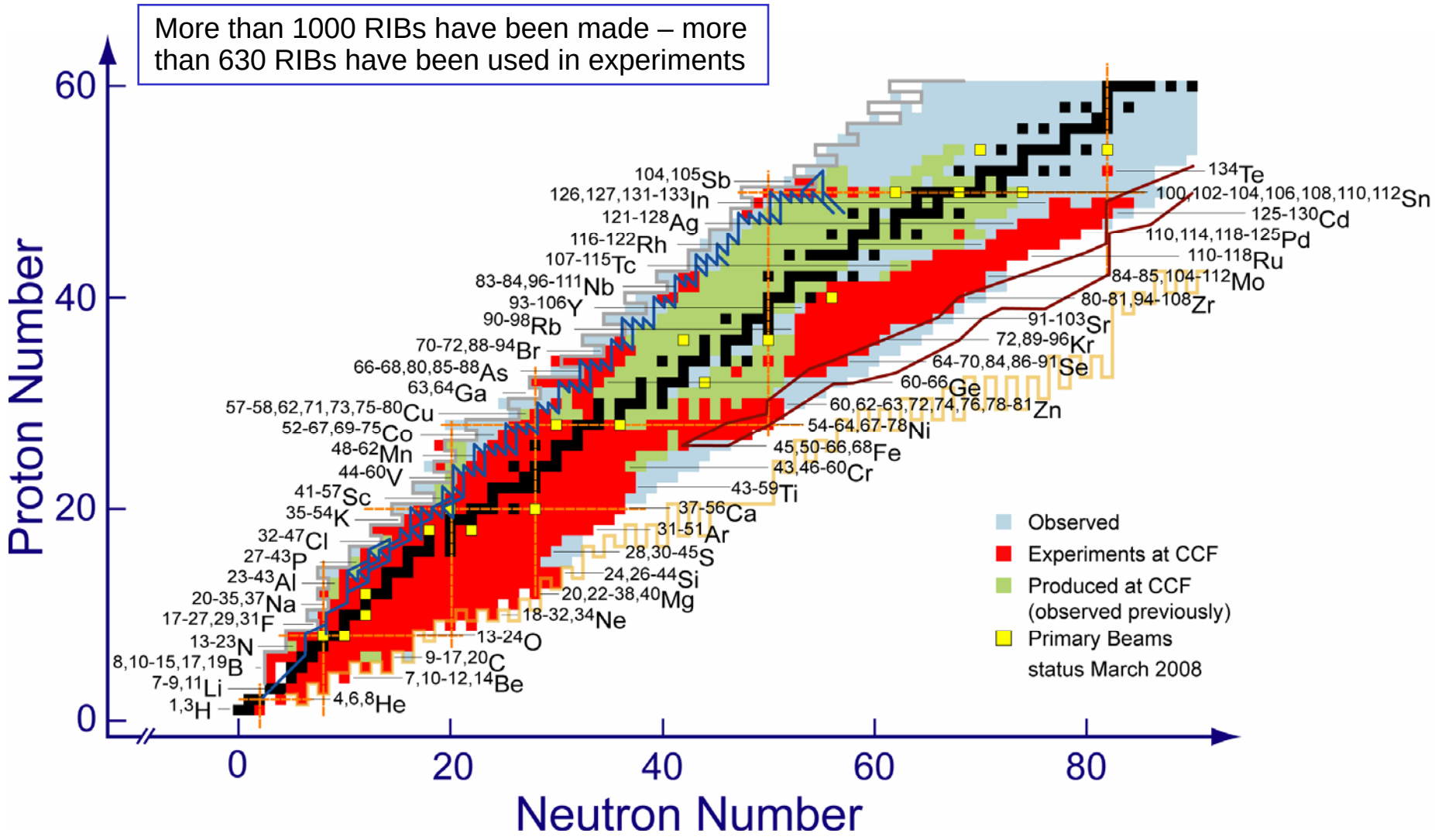
1.5×10^{17} ^{48}Ca nuclei (^{nat}W target, E/A = 141 MeV)

$\rightarrow$ three ^{40}Mg nuclei



Rare Isotope Beams produced at NSCL

On average, an experiment lasts 4 days. Research program requires large number of beam tunes and, hence, reliable and predictable operations (availability > 90%)

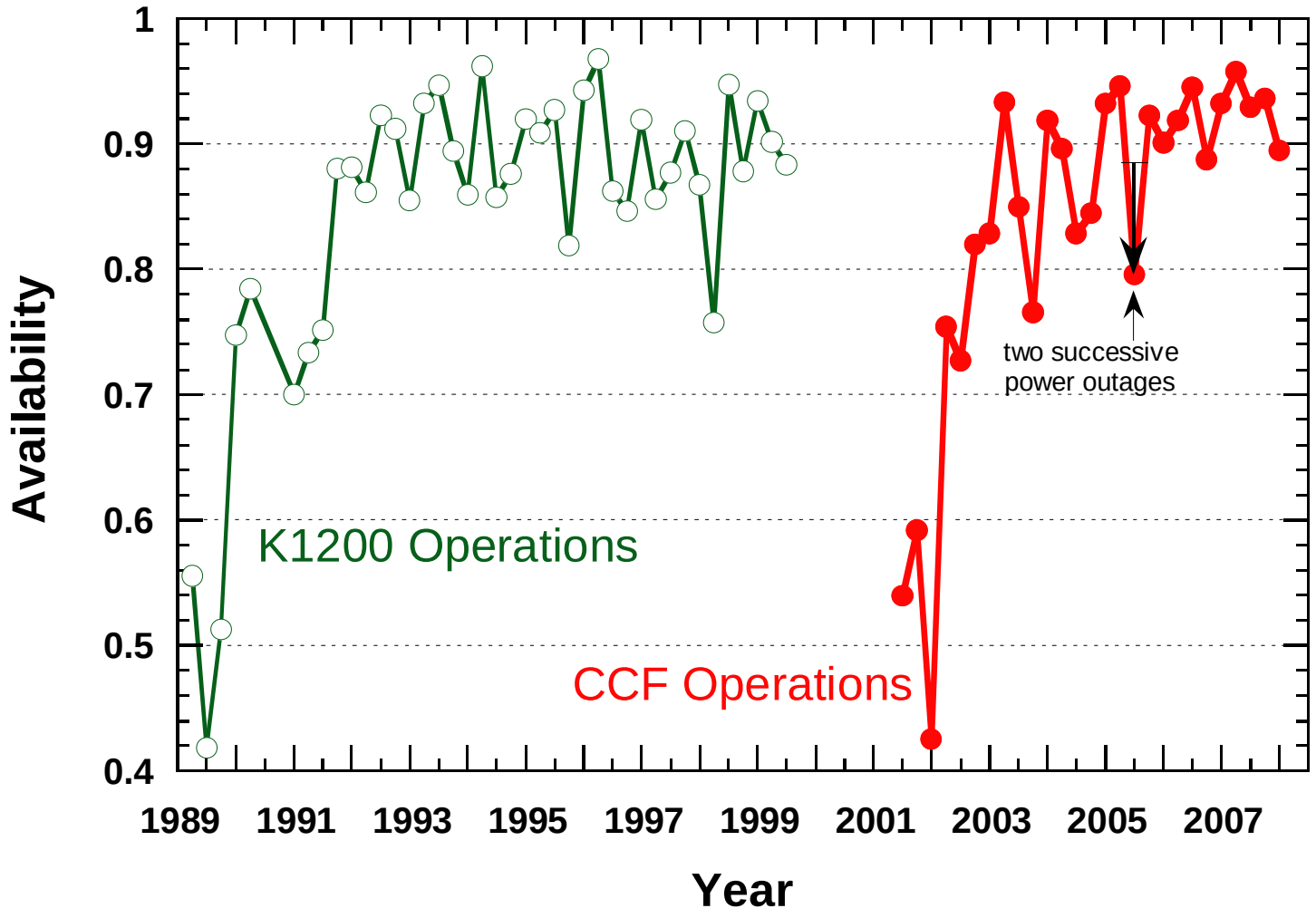


Availability (→ Predictability → User Satisfaction)

Need high availability to maintain schedule (made 3 months in advance)

Availability = actual running time/scheduled time for entire system up to user end-station

– Downtime clock runs until original beam condition is restored after failure



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Achieving high availability

- Employees are members of groups. Groups in departments have well-defined system and process responsibilities. These are reviewed annually and tied to annual.
- Department heads receive and allocate resources based on system and process responsibilities (and core competencies)
- Measure availability ε_i of systems
- Availability A is product of system availabilities: $A = \Pi\, \varepsilon_i$
- Availability A relates to Mean Time Between Failures (MTBF) and Mean Down Time (MDT): A = MTBF / (MDBF + MDT)
- Increase MTBF and decrease MDT
- Mean Down Time MDT is sum of many components
  - Recognize a problem exists, diagnose problem, repair strategy, get parts, install, test, check quality, recover operations
  - MDT can be decreased by reducing time for each step
- MTBF depends on quality
  - Design, parts, work, procedures
  - Quality engineering and quality officer, project teams

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Capture state of facility and invite corrections

02020–Stuchbery, A.

Monday,
25-Oct-2004 10:37

Spokesperson	Safety Representative	Backup Spokesperson	Experimenter in Charge
Stuchbery, A.	Andrew Davies	Andrew Davies	Paul Davidson

Source Physicist
Dallas Cole
on call

Operator
L. Gene Battin
on shift

Beam Physicist
Mauricio Portillo
on call

Device Physicist (SeGA)
Wilhelm Mueller
on call

Cryogenics Engineer
Allyn McCartney
on call

K500	K1200	Vault	Attenuator
$^{40}Ar^{7+}$	$^{40}Ar^{18+}$	N3	Actual 3
12.34 MeV/nucleon	140 MeV/nucleon		Minimum 1

Time	Status	Beam Quality
10:30	Experiment running	Primary beam satisfactory
10:15	Experiment running	Primary beam satisfactory
10:00	Experiment running	Primary beam satisfactory
09:45	Experiment running	Primary beam satisfactory
09:30	Experiment running	Primary beam satisfactory

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MICHIGAN STATE UNIVERSITY

Inform staff about availability in hallway displays

Monday, 25 Oct 2004 **10:44**

Current Experiment

02020-Stuchbery, A.

K500	K1200	Vault	Status
$^{40}Ar^{7+}$ 12.34 MeV/nucleon	$^{40}Ar^{18+}$ 140 MeV/nucleon	N3	Experiment running

	1 day		7 days		30 days		180 days	
Availability	**86.5 %**		**91.0 %**		**80.2 %**		**83.7 %**	
Scheduled Off	0.0 hrs	0.0 %	1 hrs	1 %	125 hrs	17 %	1,276 hrs	30 %
Unscheduled Off	3.3	13.7 %	15	9 %	118	16 %	496	11 %
Development	0.8	3.3 %	15	9 %	167	23 %	875	20 %
Experiment	20.0	83.3 %	137	82 %	301	42 %	1,633	38 %

Utility Shutdowns

Tour (Today 17:45-18:45)

Access Restrictions

K500 vault, K1200 vault, Transfer Hall, N3 vault secured

- System owners mention all breakdowns during prior 24 hrs in daily 8 am coordination meeting

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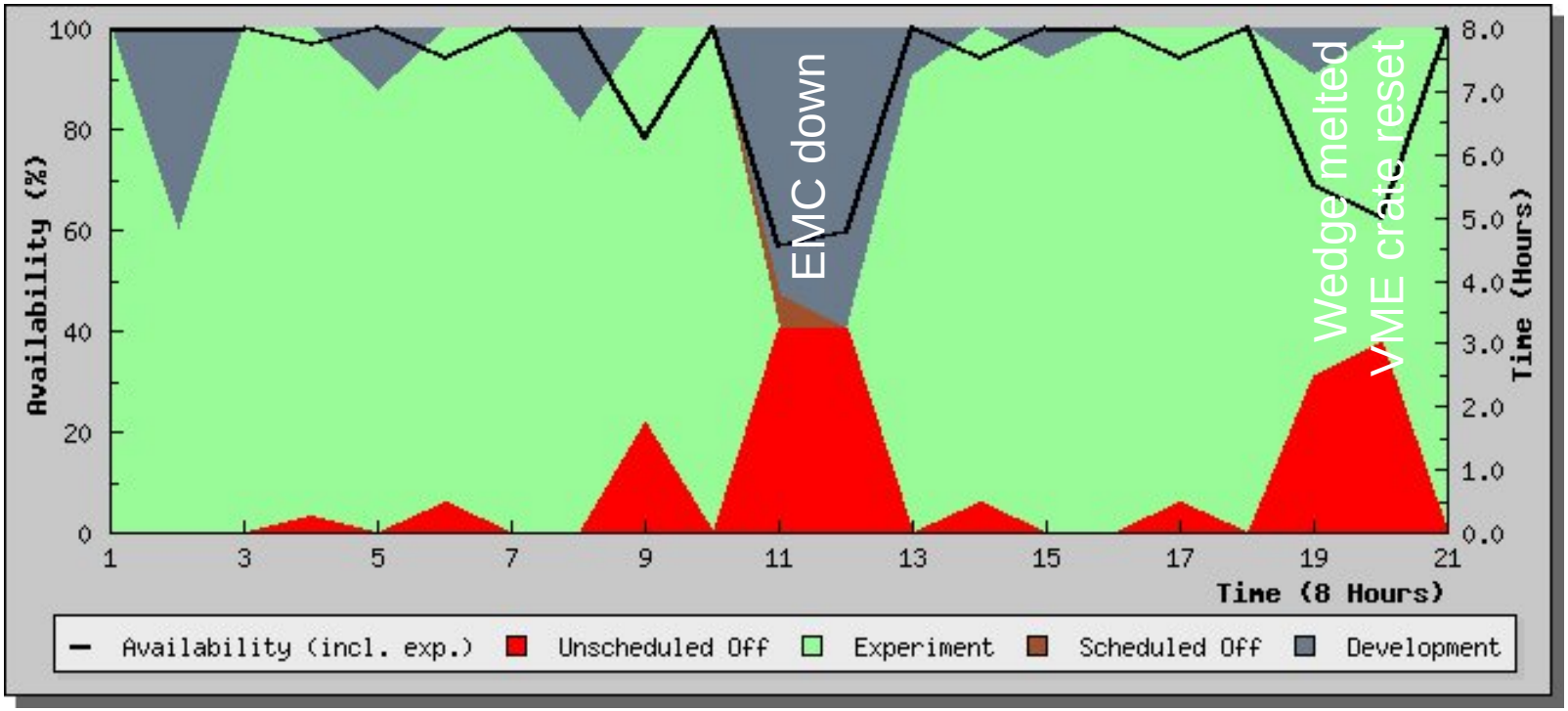
Weekly reports to all department heads and senior management

e.g. Mon 18-Oct 2004 through Sun 25-Oct 204

- Availability 90.8 %
- Off 0.5 hrs
- Running 152.0 hrs
  - Experiment 135.3 hrs
  - Tuning 16.8 hrs
- Unscheduled 15.5 hrs



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Each unscheduled downtime triggers Trouble Report

- Root cause analysis, preventive action, preventive action implemented, review by Reliability Committee, closure
  - Enlarge group of employees qualified to be investigators each year
  - Rotate line managers through Reliability Committee
- Closed over 3,500 trouble reports since 2002
- Best use of funds through value engineering
  - Use very simple rules and teach them to all employees who can affect availability
    - Cost – one rate
    - Worth – Downtime avoided
    - Amortize over 3 years
  - Deferred maintenance list

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Achieving high availability - People

- Availability is important and highly visible
- Everybody understands how they affect availability
  - Interdepencies are made explicit
  - Peer accountability in addition to line management accountability
- Align system and budgetary responsibilities
  - Example: Ion source feed material
- Watch employees do their jobs and enable them when needed
- ISO 9001 Quality Management System (third-party certification anticipated in 2008)

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Achieving a safe workplace - People

- Safety is important and highly visible
- Everybody understands how they affect their own safety and the safety of others
  - Interdepencies are made explicit
    - Work planning
  - Peer accountability
  - Anybody can stop any job at any time
    - Triggers immediate investigation by line management and Safety Office
- Safety office enables employees to work safely
  - Safety office as resource that is being sought out by employees
- Line management enforces
- Best-in-class DART rates
  - Zero transfers or lost/restricted work days since 2005
- OHSAS 18001 Integrated Safety Management system (third-party certified in 2007)

NSCL

Protecting the environment - People

- The environment is important
- Everybody understands how they and their job affect the environment
  - Best ideas for annual goals come from employees
- ISO 14001 Environmental Management System (third-party certified in 2006)
- Michigan Department of Environmental Quality awarded NSCL Clean Corporate Citizen Award in 2007

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Third-party audited management systems

- Our first tactic that did not work: Bring in an external expert who tells us what to do
  - Resulted in confusion and apprehension and cancellation of effort
- Strategy that worked for us: Build it internally
  - Identify employees who are interested, send them to auditor training, have them work with domain experts under close sponsorship of senior management to develop management system
  - Slower, costs more time
  - Very powerful, immediate buy-in
- Working with auditing company who has been willing to learn about our “business”
- Integrated employee suggestion system
- Newsletters which provide information with authority

NSCL

Human resources

- Non-academic NSCL employees organized in three unions/associations
- “Managements right to direct work” explicitly contained in all three contracts
- Most classifications for positions at NSCL unique to NSCL
- Crafts people are “Instrument Makers”
- NSCL uses MSU’s Human Resource System
  - Opportunities and challenges
- Organizational Development Consultant has helped in suggesting changes
- Extensive use of MSU and third-party “people” training for line managers

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Conclusion

- NSCL has a culture
  - Based on a shared vision with
  - Clearly articulated, measurable, and very visible outcomes and
  - Employees who know how they can influence these outcomes
  - Informal practices have evolved into formal management systems, owned by NSCL employees, for
    - Environment (ISO 14001)
    - Occupational Safety and Health (OHSAS 18001)
    - Quality (ISO 9001)
- 300 people working together safely, our actions aligned in a shared vision of NSCL being the best rare-isotope user facility where scientists make important discoveries.

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